METHOD OF IMAGE STORAGE

FIELD OF THE INVENTION

The present invention relates to a method of image storage. This method comes within the more general scope of data storage.

The storage of data has several aspects that have variable influences on the lifetime. A first aspect is the transfer of the data to a storage medium. A second aspect is the ageing of the medium. Finally, a third aspect is the retrieval of the data from the medium.

The difficulties of data storage are linked to the above aspects but also to the complexity of the data having to be stored. This difficulty is particularly great for image storage, and especially for photographs comprising fine details and subtle color shades.

In this context, the invention applies more particularly to image storage on a photographic medium.

BACKGROUND OF THE INVENTION

The recording of data onto storage media does not in itself constitute the main difficulty in the storage process. However, it is worth stressing that the apparatus used for the recording is capable of altering the saved data. For example, faults of distortion of sharpness or vignetting of a lens only allow a photographic scene to be imperfectly recorded onto a film.

There is a greater difficulty for the storage of the medium. Whether the data recording makes use of chemical, physical or magnetic transformation of the material, the medium remains subject to ageing. The thermal, chemical, atmospheric or other constraints undergone by the medium inevitably end up influencing all or part of the data. In particular ageing tends to modify the color balance of images stored on a photographic film. Color modification certainly gives old photographs a pleasing old-fashioned look, but is all the same an alteration.

Recently, media in the form of memory chips, in the form of optical disks or magnetic tape have been developed to improve data storage. These media,

onto which the data are recorded as code, prove to be particularly robust and have nourished hopes of long life.

Nevertheless, the last aspect of data storage, mentioned in the introduction, here raises a crucial problem. This concerns the reading and retrieval of the data. The evolution of recording media goes together with the form in which the data are recorded. In particular, digital recording techniques for encoded data have largely supplanted analog recording techniques. The evolution of recording media also goes together with write and read equipment. In this matter, the rapid obsolescence of many digital media and equipment can be seen, in comparison with analog media and equipment.

The retrieval of stored data thus risks being made impossible for lack of suitable reading apparatus, and still further, for lack of decoding keys. A minimum of information on the encoding technique used to format the data during their recording is indeed essential for their faithful retrieval.

SUMMARY OF THE INVENTION

The goal of the invention is to propose a method for data storage, and in particular image storage, that enables the difficulties mentioned above to be avoided.

The goal of the invention is to propose a method for data storage that is particularly long lasting, that enables data retrieval even in the case of total or partial loss of the read equipment and knowledge of the encoding modes.

To achieve these goals, the invention relates more precisely to an image storage method, comprising:

the preparation of new image data (16b) based on the initial digital data (16a) of at least one image to be stored, by modifying at least one first characteristic of said image, and the recording on a photographic medium (20) of at least one first and at least one second image in which:

- the first and second images respectively have the first characteristic unmodified and the first characteristic modified,
- the first and second images also have at least one second common characteristic, separate from the first characteristic,

- the first and second characteristics have different storage stabilities,

and in which at least one part of at least one of the first and second images is recorded in analog form having directly human-significant content.

Photographic medium means any analog medium capable of receiving images or photographs. For example, this is photographic paper, inkjet paper, or, preferably, silver photographic film.

The invention is based on the observation that the various characteristics of an image do not necessarily have the same storage stability. Certain characteristics prove to be less resistant over time, but particularly insensitive to the means or equipment used for their retrieval. However, other characteristics are more stable over time, but are tricky to retrieve.

The words "image characteristics" generally designate all the information contained in an image, the information relating to its encoding, and information capable of being derived from the digital data of the image. Without the list being exhaustive, among the characteristics of an image, the following may be cited: its color components, the permutation or distribution of the color components, the pictorial content of the image, its light components, the negative or positive character of the image, a representation format of semantic content of the image, the contrast, or again the position of the pixels of the recorded image. Pictorial content means the main forms that can be differentiated in an image, through contrast of color or light. For example, this is the general form of a tree or face that the observer can recognize in the image.

Among the image characteristics mentioned above, it may be seen that some are more or less resistant to time and more or less easy to retrieve. The color, or density of the medium, for example, is very simple to retrieve. It can be read using a scanner. However, the thermal, chemical or atmospheric constraints undergone by the medium may have greatly altered the initially recorded colors. Thus, the retrieved colors risk being different from the recorded ones.

A reverse example is given by the characteristic of the position of the pixels of the recorded image. An image can be recorded on a photographic medium either by direct exposure, or by means of scan writing equipment. Scan

writing occurs by imprinting a medium using a modulated beam. Writing, even of the analog type, occurs by exposing the medium in the form of pixels. The energy and color of the exposure light supplied by the recording of each pixel are dictated by one or more digital pixel values. The digital values of the pixel can result from a preliminary digitization of an original. The characteristic of the pixel positions on the medium, is fixed when writing the pixels using the write equipment. The position of each pixel is especially long lasting. Indeed, the ageing of the medium hardly modifies the place where the pixels were written. However, a considerable loss of information may have occurred when writing. This is especially the case when the pixels of the reading scanner are not superimposed with the pixels recorded on the medium. For example, if two or more neighboring pixels on the photographic medium have different colors and if the scanner reads in a position partially overlapping the two pixels, it will recognize an average color which is not the recorded one.

The invention is also based on the observation that the loss of information relating to the encoding of the recorded data, or that relating to their recording mode, may be compensated for, in whole or part, when at least one among the images having a modified characteristic and the image having the same unmodified characteristic have any directly human-significant content.

It is considered that an image has human-significant content when a person can recognize that it is an image and when they can recognize some characteristics of the image without having to use any special reading and/or decoding equipment. The characteristics capable of constituting human-significant content are, for example, the orientation of the image, it pictorial content, its main subject, etc.

When the photographic medium has many images, the first and second images taken together, which have an unmodified characteristic and the same modified characteristic respectively, are preferably juxtaposed or recorded with a link mark so that the user can recognize their relationship. It is worth stressing that the words "first" and "second" image are used to differentiate the image with the unmodified characteristic and the image with the modified

characteristic. They should not be interpreted in a sense that would limit the number of images taken together to two. More images, of which at least one has a modified characteristic and at least one other has the same unmodified characteristic, can be taken together.

When the images are those of a motion-picture sequence, they can be recorded on a film respecting the order of the sequence, or an order clearly specified on the same film.

In a particular embodiment of the invention method, the first characteristic can be one chosen from among the orientation of the image, the positive or negative character of the image, an order of switching color components, a representation format of semantic content and the pictorial content of the image.

When the image is, for example, the representation of a handwritten page of a literary work, the text, which is one characteristic of the image, can be modified and recorded on said second image in printing characters or even in the form of printer codes. These characters or this code then constitute semantic content as previously mentioned.

The second characteristic can be chosen from among the position of the pixels of the image, the pictorial content of the image, and a range of exposure energies, or again from among the other previously mentioned characteristics. Examples of choice of modified and unmodified characteristics are given in the rest of the description.

The first and second images taken together can be exactly identical apart from the modified characteristic. This is the case when the image data of the first image are used to modify one characteristic and to create the second image taken together. However, the exact identity of the other characteristics is not required. Thus, with the exception of the modified characteristic, the other characteristics can be identical or very slightly different for the images taken together.

It is considered that the characteristics of two images are only very slightly different when the gap between the characteristics does not exceed that observable between two successive images of a motion-picture sequence.

The possibility of not maintaining the other image characteristics exactly identical is indeed particularly advantageous when the images to be stored are the successive images of a motion-picture sequence. Given the shooting rate, two consecutive images of the same shooting sequence are generally little different. In this case, the differences present between two successive shots are sufficiently weak to select the two successive shots as images taken together. The modification of one of the characteristics can thus be simply performed on one of the consecutive images of the sequence.

Other characteristics and advantages of the invention will appear in the following description, with reference to the figures in the appended drawings. This description is given purely as an illustration and is not limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flowchart showing the main implementation steps of a method according to the invention.

Figure 2A illustrates four successive shots of a motion-picture sequence, provided to be stored according to a method according to the invention.

Figure 2B illustrates one possibility of recording the four shots of figure 2A.

Figure 3A shows the four shots of figure 2B having undergone an alteration.

Figure 3B illustrates an intermediate restoration step of the shots of the previous figures during an image retrieval step that is not part of the invention method.

Figure 4 shows the images taken together illustrating another implementation option of the invention method.

Figure 5 shows the images taken together illustrating yet another implementation option of the invention method.

Figure 6 shows the images taken together also illustrating yet another implementation option of the invention method.

Figure 7 again shows the images taken together illustrating an implementation option of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Various possible embodiments of the invention are described below. They are not exclusive one from another.

Figure 1 shows a very simple application of the method for storing an image 10. The image 10 is, in the described example, a photograph of a tree. One preliminary step, indicated with the reference 12, comprises the collection of image data that are to be used in the implementation of the storage method. In this case this is the digitization, using a scanner, of the source image 10.

The digital data are used in a next step 14 of preparing new data. During this operation one or more characteristics of the image are stored and one or more other characteristics of the image are modified. Thus two image data sets are obtained. A first data set, marked with the reference 16a corresponds to the image whose characteristics are not modified and the second data set 16b corresponds to the image with the modified characteristics. For reasons of clarity of the figures, the data sets 16a and 16b are represented summarily with the image to which they correspond, in this case the tree.

The first data set 16a corresponds to the source image 10. The second data set 16b corresponds to the image 10 of which one characteristic, the orientation, has been modified. For simplification, the first and second image data sets are simply designated below by "first image" and "second image" and no longer differentiating between the image and the image data. The references 16a and 16b are also used indifferently for images and image data.

In the example described here, the first image 16a corresponds exactly to the source. However, this does not constitute a necessary condition. A number of characteristics of the source image can be contained in the second image without appearing in the first image or visa versa. The first and second images simply play a complementary role such that one modified characteristic in one of

the images appears unchanged in the other image. However, and again for simple reasons of clarity, it is considered that the first image is identical to the source and that the second image comprises the modified characteristics.

With the exception of the characteristic of the orientation, the first and second images 16a, 16b also have common characteristics. In this case this is the pictorial content, i.e. the tree.

The images 16a and 16b are routed to writing equipment 18 that delivers, according to the image data, a writing beam 19. The beam enables the recording of the images on a medium that, in this case, is a silver photographic film 20. The writing equipment can be adapted to the selected recording medium. It can be a simple inkjet printer.

Finally the photographic film bears the two images 16a and 16b. These are analog images with human-significant content, even if they are formed of pixels dictated by the image data and writing equipment. In the described example, the human-significant content is the fact that it is an image, that this image represents a tree and that this image is recorded with two opposite orientations. Here, the fact that the pictorial content is unchanged, enables the modification of the orientation characteristic to be accounted for.

An additional step, not represented here, comprises the development of the film 20 to transform the latent image formed by the recorder 18 into a real image.

The next figures illustrate particular embodiments of the method.

Figure 2A shows a succession of images 101a, 102a, 103a, 104a of a motion-picture scene. The images are not exactly identical. The main subject, a palm grove, is offset according to the panning performed by the camera. The palm grove, or at least one part of it, is visible on all the images. It constitutes pictorial content that is directly human-significant. Figure 2B shows the images 101b, 102b, 103b, 104b recorded on the photographic medium for their storage.

The image 101b is identical to the image 101a. The image 102b is an axial symmetry of the image 102a. The image 103b corresponds to the image

103a. Finally, the image 104b has undergone a one-off symmetry in relation to the image 104a.

One of the images 101b, 102b, 103b, 104b, for example the image 101b, is here considered as the first image within the meaning of the invention. The other images 102b, 103b, and 104b are thus considered as the "second images" within the meaning of the invention. They have one "first characteristic", in this case the orientation or symmetry, modified in relation to the first image. However, the "second images" have one or more "second characteristics" in common with the first image. For example, these are the color components, the position of the pixels, a range of exposure energy or the pictorial contents. Here the pictorial content is the palm grove. The second common characteristic of the images is not strictly identical for all the images for the reason given above, i.e. the panning of the movie camera. If the variation of one characteristic considered as common is too great during a subsequent operation of image reconstruction, this characteristic may only be considered for one part of the image in which it varies little. For example, for the images 101b, 102b, 103b and 104b, this would mean only considering the part corresponding to the central group of palm trees.

Figure 3A shows an alteration 106 of the film bearing the images of the recorded motion-picture scene. This is shown by the hatching. The alteration 106 is for example a modification of the density of one or more of the film's color layers. This is demonstrated by fading of the film and modification of the color balance. The alteration 106 does not affect the whole film surface but forms a lateral strip on a small margin of one side. Such a strip results for example from the anisotropic exposure of the film to a chemical agent.

When the images of the film have to be retrieved, direct visual inspection enables the user to identify the set of rotations and symmetries assigned to successive images. This is due to the fact that the images are recorded in an analog form having human-significant content. Indeed, the user recognizes the position reversal, or overturning of the palm trees that constitute the pictorial content of the image.

Based on this information, it is possible to retrieve the original sequence of images easily with their initial orientation. The retrieval can occur, for example, by scanning the images of figure 3A and by modifying the order of the pixels to retrieve the symmetry and orientation of the images. This operation is illustrated by figure 3B. It may be observed that the alteration 106 is no longer present as a strip but is found alternately on one side and on the opposite side of the images.

A correction of the color density can then occur by using neighboring images of the succession of images. For example, density and color data taken from a region 107 of the image 102b of figure 3B can be used to correct the density or color data of the pixels of the corresponding parts of the image 101b that has the alteration 106. In the illustrated case, where the images correspond to the successive shots of a motion-picture scene, vectorization of the movement of the elements of the pictorial content of the images enables the parts to be corrected to be matched to the parts supplying the data for the correction.

Similarly, the unaltered part 108 of the image 101b can be used to correct the data of the altered part 106 of the image 102b. The image data can thus be reconstructed closer and closer to recover an image succession identical to the succession initially recorded and corresponding to figure 2A.

Figure 4 illustrates another implementation option of the invention for storing handwritten documents. A first image 201 represents the handwritten document. It is obtained by scanning the document or by scanning a photograph reproducing the document. A second image 202 is taken together with the image 201, it does not reproduce the document but only the handwritten text. This text can be reproduced as printer characters 203 or possibly as character codes 204 (ASCII American Standard Code for Information Interchange). The printing characteristics, as well as the handwritten characters are directly human-significant.

The two images thus have different pictorial contents, possibly different color components, but the same semantic contents, in this case the text. If an alteration 206 of the first image 201 appears, deleting all or part of the

characters, the text can be read from the second image. Indeed it proves to be easier to read a partially deleted printed text than a partially deleted handwritten text, because the non-visible part of the characters can be more easily guessed at. By knowing the initially handwritten text, the image restorer can reproduce the deleted part 206.

Another implementation option of the invention is illustrated by figure 5. Figure 5 represents a first image 301a with human-identifiable pictorial contents. This is the famous palm grove. A second image 301b, taken together with the first image does not have the same pictorial contents but has an identical range of exposure energy. More precisely, each column of pixels of the image 301b has a regular density gradation corresponding to the overall exposure range of the image 301a. The images taken together comparable to the image 301b can be recorded for each color component.

The reference 306 indicates the same alteration affecting the images 301a and 301b. The altered zone, hatched in the images, is for example a fading of the images in one or more color components. This fading is not necessarily uniform and can affect more or less dense parts of the images differently. The altered part of the image 301b does not enable the reconstruction of the altered part of the image 301a. However, it is considered here that the two images 301a and 301b have undergone the same alteration. However, it is sufficient for one of the pixel columns of the image 301b to be intact to have the whole exposure range. This pixel column can then be used to establish the look up tables (LUT) then applied to the altered part 306 of the image 301a. More precisely, a look up table can be established for each column.

When the exposure range of each column of the second image 301b corresponds with that of the first image 301a, one altered column A of the first image can be retrieved using a look up table LUT established between one corresponding column A' of the second image and one unaltered column B of the second image. The data of the unaltered column B enable the alterations undergone by the pixels of column A' to be measured. By considering that the columns A and A' have undergone the same alteration, the pixels of column A of the image 301a

are corrected according to the existing differences, line by line, between the pixels of columns B and A' of the image 301b.

Figure 6 illustrates yet another implementation option of the invention. Two images taken together 401a and 401b have the same pictorial contents. However, their distribution of luminance or color is different. The image 401b is the negative of the image 401a. The pictorial contents are also the same. The negative is obtained by replacing, for example, the digital code x of each pixel by a code equal to 255-x, or 1023-x when the density is encoded on 8 or 10 bits respectively.

In a more sophisticated way, for a color image, the pixels of a given color can be recorded in different color layers of the film. For example, the red, green, blue color components of the pixels can be recorded in red, green, blue layers for the first image, 401a in green, blue, red layers for one of the second images 401c and in blue, red, green layers for yet another image 401d. Other linear permutations or combinations of the color components for recording the color layers are possible. This type of recording of images taken together can benefit from the fact that the different color layers have different storage properties over time. The different color layers of a medium, in this case a film, indeed contain different dyes having different resistances over time. The set of color permutations enables information relating to a given pixel to be stored in different color layers. Thus, the evanescence of one color of one layer will only affect information in one of the images taken together.

Another example of implementing the invention is again given by figure 7. The image 501a constitutes the first image in the meaning of the invention. This image is formed of pixels 502a represented by broken lines. For reasons of figure clarity the dimensions of the pixels are considerably exaggerated. Contrary to what the figure might suggest, it should be noted that each pixel has one color and uniform density. The shades of color and density come from the juxtaposition of the pixels.

By ignoring any generally minimal distortions of the photographic medium, the position of each pixel in the image is a particularly robust

characteristic of the image. However, it is a characteristic of the image that is very sensitive to the retrieval processes and equipment.

When the retrieval equipment has the same spatial resolution as the equipment writing the pixels onto the photographic medium, it is possible to read the image and break it down into pixels that have the same area as the pixels of the recorded image. In the rest of the text, to differentiate the pixels read by the reading equipment and the pixels recorded on the photographic medium, they are designated as "read pixels" and "write pixels" respectively.

Correct retrieval of the recorded images is only possible when the read pixels coincide exactly with the write pixels. An illustration can be given by an example. When a high-density red write pixel juxtaposes a low-density blue pixel, and a read pixel partly overlaps the two neighboring write pixels, the retrieval equipment delivers a signal corresponding to a medium-density pixel whose color is a combination of red and blue. To perfectly retrieve the color component of the write pixel, and its density, the read pixel must exactly superimpose the read pixel.

The negative effect of the alignment errors between the read pixels and the write pixels can be reduced when the resolution of the read equipment is much greater than the resolution of the equipment used for writing. In other words, the negative effect is attenuated when the read pixels are smaller than the write pixels. However, it can only be completely eliminated when an exact superimposition is achieved.

It is especially difficult, when reading the image 501a, to identify the exact position of the write pixels. In particular this stems from the fact that neighboring pixels can have more or less the same density and the same color components. However, the image 501b, which is taken together with the image 501a, has pixels according to a high-contrast graphic grid, like a checker board. It is for example a black and white checker board. The characteristics modified in relation to the image 501a are, for example, the pictorial contents and the color components. The common characteristic is the position and size of the pixels in the image. The image 501b can thus be used to position the read equipment used for

reading and retrieving the image 501a. The positioning of the read equipment occurs, for example, by successively reading the image 501b, and by offsetting the read equipment each time until a read signal is obtained whose amplitude between the dark pixels and the light pixels of the checker board is maximum. Then, the first image 501a can be read with the same equipment, by storing the positioning established with the second image 501b. The positioning of the equipment according to the second image can be completed by calculating an exact positioning to correct the very small offsets of the equipment. This calculation is possible especially when the "read" pixels have a surface area less than the "write" pixels. In particular, when the read pixels are four times smaller in surface area than the write pixels, it is possible to guarantee that at least one read pixel is inscribed in a write pixel. The correction is made so as to determine the read pixel whose center is nearest that of the write pixel. The value of the read pixel is then used.